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Water Pollution Survey of the Wabigoon River

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ONTARIO WATER RESOURCES COMMISSION

A WATER POLLUTION SURVEY
OF THE
WABIGOON RIVER

by

M. J. German

BIOLOGY BRANCH
DIVISION OF LABORATORIES

an/c

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SUMMARY AND RECOMMENDATIONS

During the period between June and September, 1968, investigations were undertaken which were designed to delineate the nature, degree and extent of the effects of wastes from the Dryden Paper Company Limited on the Wabigoon River.

The observed physical, chemical and biological conditions support the conclusion that gross organo-toxic pollution exists throughout a lengthy portion of the Wabigoon River.

Results of experimental netting carried out by the Department of Lands and Forests showed that seven species of fish, four of which were game species, were present in the Wabigoon River above the pollution source. Below the discharge of the pulp mill effluent, no fish of any species were secured at the 15-mile range. At the 41-mile range, only the common white sucker had re-established. One species of game fish (walleye) re-populated the river at the 52-mile range, near the discharge to Clay Lake. These findings are similar to the results of a survey carried out in 1951.

A diverse association of fish food organisms (bottom fauna) occurred in the river above the discharge of the pulp mill effluent. Below the mill, both the variety and abundance of these fauna were restricted for a distance of 27 miles. Several samples were entirely void of bottom fauna. Between the 27- and 39-mile ranges, communities of these organisms remained imbalanced but considerably improved. Normal communities were re-established below the 39-mile range. From east to west in Clay Lake, a normal to imbalanced shift of bottom fauna communities was apparent.

Dissolved oxygen depletion below the pulp mill was critical to a distance of 39 miles. Normal levels of oxygen were restored immediately below both High Falls and Quibell Falls. A slight decline in dissolved oxygen was evident between Quibell Falls and Clay Lake. Severe oxygen depletion was detected in the hypolimnetic (bottom) waters of the western basin of Clay Lake.

Emmission of offensive odours was detected from the surface waters of the Wabigoon River between the point of discharge of the mill effluent and the 27-mile range.

Surface waters of the entire river below the mill and the eastern portion of Clay Lake exhibited a high potential to foam.

Pulp wastes were observed to blanket the entire river bottom to a distance of 27 miles below the mill. Isolated beds of these same wastes were common downstream to the 39-mile range.

Visible conditions of the river and its shoreline were aesthetically objectionable downstream to the 27-mile range. Surface water discolouration, foaming, bubbling of escaping gases, shoreline litter, sludge-bank formations and floating fibre mats were characteristic of this upper river reach.

At the present time, little or no use is made of the Wabigoon River aside from the over-utilization of its capacity to translocate and assimilate wastes; however, in the past the Wabigoon River has supported a variety of beneficial water uses. Those which have been obviated by pollution include sport and commercial fishing, agricultural utilization, boating and aesthetic enjoyment. The most noteworthy of these effects has been the complete collapse (since 1958) of an 8,000 lbs/year commercial fishery formerly carried out on Clay Lake, owing to fish tainting problems. Potential uses jeopardized by existing conditions include both domestic and industrial utilization, as well as all forms of shoreline development for recreational endeavours.

To date, efforts made by the industry have been directed towards in-plant control, either with or without some economic returns for the expenditures incurred. While good housekeeping practices are necessary, the law of diminishing returns usually restricts the level of effluent improvement which can be expected by in-plant control. Further reductions can only reasonably be expected to be accomplished by some form of external treatment.

In view of existing river conditions and the associated effects on multiple water use and considering the incapability of in-plant controls to provide adequate protection for the receiving water, it is recommended that appropriate action be taken without delay to bring about an effluent quality compatible with the Commission's objective.

Specifically, in order to rehabilitate the Wabigoon River to an acceptable quality for multiple use, it is recommended that the Dryden Paper Company Limited undertake the design, implementation and maintenance of treatment facilities to:

(1) Reduce waste loadings of oxygen-consuming components to a level which will ensure the continuous maintenance of not less than 5 ppm dissolved oxygen throughout the Wabigoon River.

(2) Reduce waste loadings of suspended solids to a level which will prevent harmful deposition of fibre and other materials, thus protecting aquatic life and maintaining the aesthetic quality of the river.

(3) Reduce or remove from the dissolved solids loading, those components which may impart acute or sub-lethal effects on aquatic life, tainting of fish flesh and discolouration, odour or foaming in the receiving water.

(4) Provide adequate protection against accidental spillage of waste materials.

In order to restore some of the river's natural aesthetic quality it is further recommended that:

(5) The company remove pulp mill wastes which have accumulated in the river between the mill and the Wainwright Dam.

INTRODUCTION

In 1913 pulp mill wastes were first discharged to the Wabigoon River at Dryden. Since that time, pollution of the Wabigoon River has been a continuous source of concern for area residents, government agencies and conservationists.

Expressions of local concern noted in Commission files relative to the situation on the Wabigoon have been received from the Dryden District Farmers' Association (1937), Dryden Camp Owners' Association (1954), Kenora Resort Operators' Association (1959), Ontario Council of Commercial Fisheries (1959), Northern Ontario Tourist Operators' Association (1960), Kenora Outfitters' Association (1960) and the Kenora District Camp Owners' Association (1960). These communications attest to the importance attached by area inhabitants to the potential multiple water uses of the Wabigoon system.

Gross pollution of the Wabigoon River was revealed by a survey carried out in 1951 by the Department of Lands and Forests, in which no fish were found to exist to a distance of approximately 40 miles downstream from Dryden(1). Since that date, substantial reductions in waste loadings have been made by the industry. However, notwithstanding these efforts, annual industrial waste surveys carried out by the Commission since 1958 have revealed an effluent quality which has neither satisfied nor even reasonably approached the Commission's objectives.

In order to clarify the above statements it is necessary to point out that prior to the mid-1950's, waste loadings from the pulp mill were extremely high in relation to the Commission's current objectives. Estimated concentrations of suspended solids were in the order of 3,000 ppm whereas the Commission's long-term objective was and is 15 ppm. Further, during the 1950's, mill production and water consumption increased substantially and the mill processes underwent a change through the addition of a bleachery, all of which adversely influenced the quality of the effluent discharged to the river.

In order to assessthe present status of pollution and to provide a basis for evaluating the required changes to bring about improved effluent quality, a water quality survey of the Wabigoon River and contiguous waters was undertaken during the period from June to September, 1968.

GENERAL DESCRIPTION OF THE STUDY AREA

The Wabigoon River forms at the outflow of Wabigoon Lake within the Town of Dryden, District of Kenora in Northwestern Ontario. From Dryden, the river winds westerly for approximately 100 miles, passing through Clay Lake and eventually joining Ball Lake and the English River System.

Several features of the Wabigoon River have a significant influence on water quality and the capacity of the river to assimilate wastes. The Wainwright Dam, which is located roughly 3½ miles downstream from the discharge of the pulp mill effluent, in the past has acted as an extensive settling basin for the removal of heavier suspended solids. In addition, dilution from clean-water tributaries and reaeration afforded by falls and rapids greatly enhance the assimilative capacity of the river. River flow, which more than doubles over the 53 miles of river between Dryden and

Clay Lake, is augmented by clean water inputs from the Eagle River as well as Gullwing, Rugby, Shoshowae, McLean, Beaver, Mutrie, Colenso, Buller and Bowden creeks. Re-aeration occurs at Dryden Falls, Wainwright Falls, High Falls and Quibell Falls, as well as at the Mutrie Rapids. All of the above features equip the Wabigoon River with a greater-than-normal waste assimilation capacity, which under reasonable waste loadings should maintain satisfactory water quality throughout the river. Significant features of the Wabigoon River system are illustrated in Figure 1.

Flow of the Wabigoon River is regulated for generation of power at Dryden and Eagle River. Water flow records[1] for the Wabigoon River near Quibell (drainage area, 2,460 square miles) for the period from December 1953 to September 1965 indicate a 12-year mean discharge of 1,580 cfs. Monthly mean flows at Quibell during the study period were:

June - 2107 cfs
July - 1933 cfs
August - 968 cfs
September - 1250 cfs

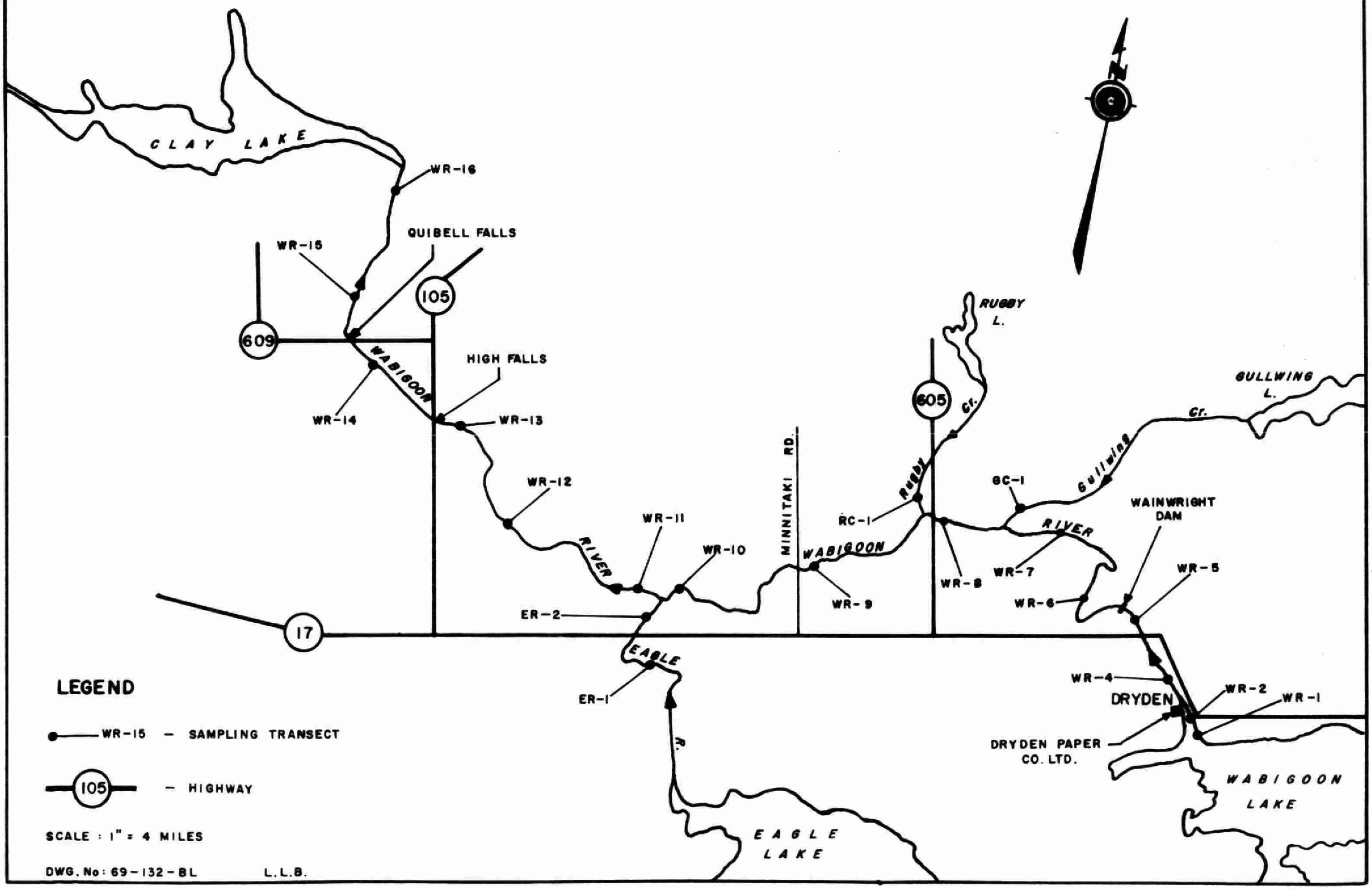
WATER USES

The earliest recorded history of the Wabigoon River system dates back to the 1730's. Prior to that date, the river, it's fish, game and wild rice belonged to the Ojibway Indians. During the 1730's, the river became established as an important transportation route which allegedly was used on one occasion by the famous explorer La Verendrye, but which was of greater significance for its use by fur traders travelling to and from trading outposts of the Northwest Company situated on the shores of Clay Lake and Ball Lake.

[1] 'Surface Water Data' - Inland Waters Branch, Department of Energy, Mines and Resources.

FIG. - 1

WABIGOON RIVER SYSTEM SHOWING SURVEY SAMPLING LOCATIONS

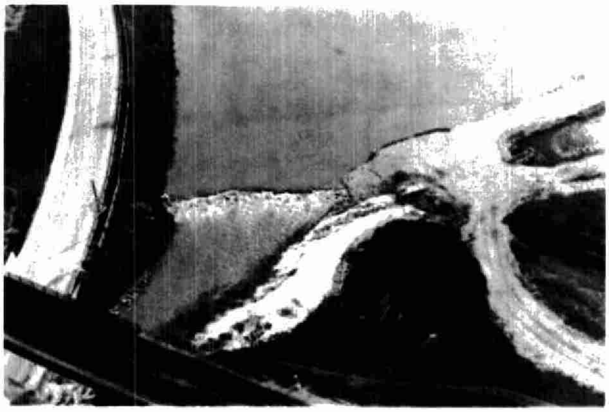


Modern history of the Wabigoon River commenced a century and a half later with clearing of the land for farming and permanent settlement. Much of the shoreline and surrounding land was cleared to a distance of 15 miles downstream from Wabigoon Lake. Along with this development came limited use of the Wabigoon River for agricultural purposes and intensified utilization of a lucrative river fishery.

In 1910, the Town of Dryden was incorporated and a dam was built to control river flow for generation of power. Three years later, in 1913, a pulp mill commenced production in Dryden and the river was used for the translocation and assimilation of wastes, a condition which has existed since that time.

During the 1920's, a commercial fishery was initiated on Clay Lake and more recently the recreational potential of Clay Lake has been developed. Further downstream, one of Northern Ontario's famous fly-in tourist camps has been located on the shores of Ball Lake.

The major waste load discharged to the river originates from the Dryden Paper Company Limited. This mill operates a conventional bleached kraft process which results in a daily discharge of 30 million gallons of waste water. Some pre-treatment of this waste water is provided prior to discharge. This is in the form of coarse solids removal and other in-plant controls. Characteristics of the effluent include high suspended and dissolved


Sewer outlet to the Wabigoon River from Dryden Paper Company Limited. Note foam formation and discolouration of river water as wastes are mixed. Sept. 1968.

solids content and the presence of components resulting in surface water odour and foaming and the tainting of fish flesh.

Sanitary wastes from the Dryden Paper Company Limited are combined with process wastes and discharged without treatment to the Wabigoon River.

Domestic wastes from the Town of Dryden (1968 population, 6,727) are discharged to the Wabigoon River following primary and secondary treatment. The Dryden Water Pollution Control Plant commenced operation early in 1968 and was providing treatment of domestic wastes during the period of this investigation.

HISTORICAL REVIEW OF POLLUTION IN THE WABIGOON RIVER

Reference to Commission files reveals that attention was drawn to the adverse effect of pollution on fish in the Wabigoon River as early as 1937. A survey carried out in 1951 by the Department of Lands and Forests indicated the absence of fish in the Wabigoon River to a distance of 39 miles downstream from Dryden(1). The report of this survey states:

> " No fish of any species were captured nor were any observed during the time the work was being undertaken."

Fish populations of downstream Clay Lake were apparently unaffected by water quality until more recent years. The earliest reported influence of pulp wastes on the fishery of Clay Lake appeared in a letter from Mr. W. Booi, commercial fisherman and resort operator on Clay Lake. In his letter Mr. Booi states:

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> " On or about December 1, 1957, we detected a pollution situation that was contaminating the fish of Clay Lake and the Wabigoon River." *

A second letter dated January 28, 1958 from the Ontario Council of Commercial Fisheries to the Department of Lands and Forests makes reference to this same situation. A quote from the letter reads:

> " Montreal fish buyers have refused two shipments of fish from this lake (Clay Lake) because of a most disagreeable smell. The smell apparently is noticable when the fish are caught and is believed to be due to effluent from the paper mill at Dryden."

Communications with the Department of Lands and Forests indicate that tainting of fish flesh is still a problem in Clay Lake. One letter dated at Kenora on the 27th of April, 1966 states:

> " During the early part of last winter we had a complaint regarding the above problem which was the rejection of a shipment of whitefish taken from Clay Lake. Commercial fishing was immediately suspended."

Commercial catch records from Clay Lake obtained from the Department of Lands and Forests (listed below) support the above statements as well as indicating the magnitude of damage incurred to the commercial fishery on Clay Lake.

Table 1. Commercial catch records from Clay Lake,1953-1968.

Year	Total landing in pounds
1953	6,436
1954	7,763
1955	9,100
1956	3,838
1957	14,559
1958	1,512
1959	no fishing
1960	437

.....continued

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* The paper mill commenced production of bleached kraft pulp during 1957 (Pulp and Paper Directory).

Table 1. continued...

Year	Total landing in pounds
1961	418
1962	no fishing
1963	298
1964	226
1965	104
1966	198
1967	132
1968	no fishing

Following market rejection of fish captured in 1958, only trial sets have been made to test fish flavour.

SURVEY METHODS

The study area covered by this report includes approximately 70 miles of the Wabigoon River, three tributaries and four connected lakes. Figure 1 illustrates the study area.

Field sampling was carried out during the months of June, July, August and September of 1968, employing techniques as outlined hereafter.

Fishing

Standing crops of fish were examined on August 7, 8 and 9 employing test gill-nets and equal units of effort at each sampling location. One-night sets were made employing a single gang of nets which contained fifty-foot sections of each of the following mesh sizes - 1½", 2", 2½", 3", 3½", 4", 4½" and 5". Fish secured were identified to species, enumerated, measured, weighed and sexed. Personnel of the Fish and Wildlife Branch, Department of Lands and

Forests, Kenora District carried out this phase of the water quality investigation.

Bottom fauna

Five replicate Ponar-dredge samples of the sediment were secured from each transect sampled along the river and its tributaries. Facing downstream, the samples were secured at five equally-spaced stations from the left to right shores of the transect. Sediments obtained were sifted through a box-screen (24-mesh-per-inch) and the invertebrates retained were picked into vials of 95% alcohol and returned to the laboratory for microscopic identification and enumeration.

The four lakes examined were sampled using varying degrees of intensity along pre-designated transects. A total of 90 bottom fauna samples were secured from Clay Lake, 50 from Wabigoon Lake, 15 from Rugby Lake and 35 from Eagle Lake. All samples were obtained with a Ponar dredge and were handled in the same manner as the river samples.

Dissolved oxygen

The dissolved oxygen profile of the Wabigoon River was established by an intensive sampling programme carried out by staff of the Water Quality Surveys Branch, Division of Sanitary Engineering,during September 17, 18 and 19, 1968.

Threshold odour

Surface water samples at seven locations on the Wabigoon River and a single location on the Eagle River were secured for threshold odour determinations. Samples were collected on July 9th and shipped air express from

Fort William to the Biology Branch laboratory in Toronto. These tests were carried out by a panel of four or five members, in accordance with procedures outlined in Standard Methods.

Suspended wood fibre

In order to identify quantitatively the horizontal distribution of suspended wood fibre in the Wabigoon River, water samples were secured and examined at 200X magnification using a Sedgwick-Rafter counting cell. Numerical results were recorded in areal standard units (a.s.u.) per millilitre. One areal standard unit is equal to an area of 400 square microns.

Precipitated pulp wastes

A Ponar dredge was employed to secure samples of the river sediment. Each dredging received gross examination in the field and the components were classified in order of relative abundance.

RESULTS

Fish

The variety and distribution of fish life in the Wabigoon River and its major tributary, the Eagle River, were determined by experimental gill-netting. No attempt was made to quantify population densities. Species secured were: northern pike, *Esox lucius*; walleye, *Stizostedion vitreum vitreum*; yellow perch, *Perca flavescens*; rock bass, *Ambloplites rupestris*; whitefish, *Coregonus clupeaformis*; tullibee, *Coregonus artedii*; white sucker, *Catostomus commersoni* and northern redhorse, *Moxestoma macrolepidotum*. Of these, all but the whitefish and tullibee, which normally frequent still waters, would be expected to range freely throughout the river under normal conditions. The actual distribution is indicated in Figure 2.

Normal water quality was indicated by the fish life present at both control stations. Seven of the eight species listed were present in the Wabigoon River upstream from Dryden and six species were present in the Eagle River.

Severe depletion of fish life was evident throughout most of the river downstream from Dryden. No fish of any species were present at the 15-mile range, nor would any be expected to inhabit the oxygen-depleted waters downstream to High Falls, a distance of 39 miles (see page 15). Between High Falls and Quibell Falls, at the 41-mile range, the river was re-populated by white suckers but no game fish were detected. Return to near normal conditions was indicated at the 52-mile range near the discharge of the Wabigoon River to Clay Lake, at which location walleyes were taken.

Bottom fauna

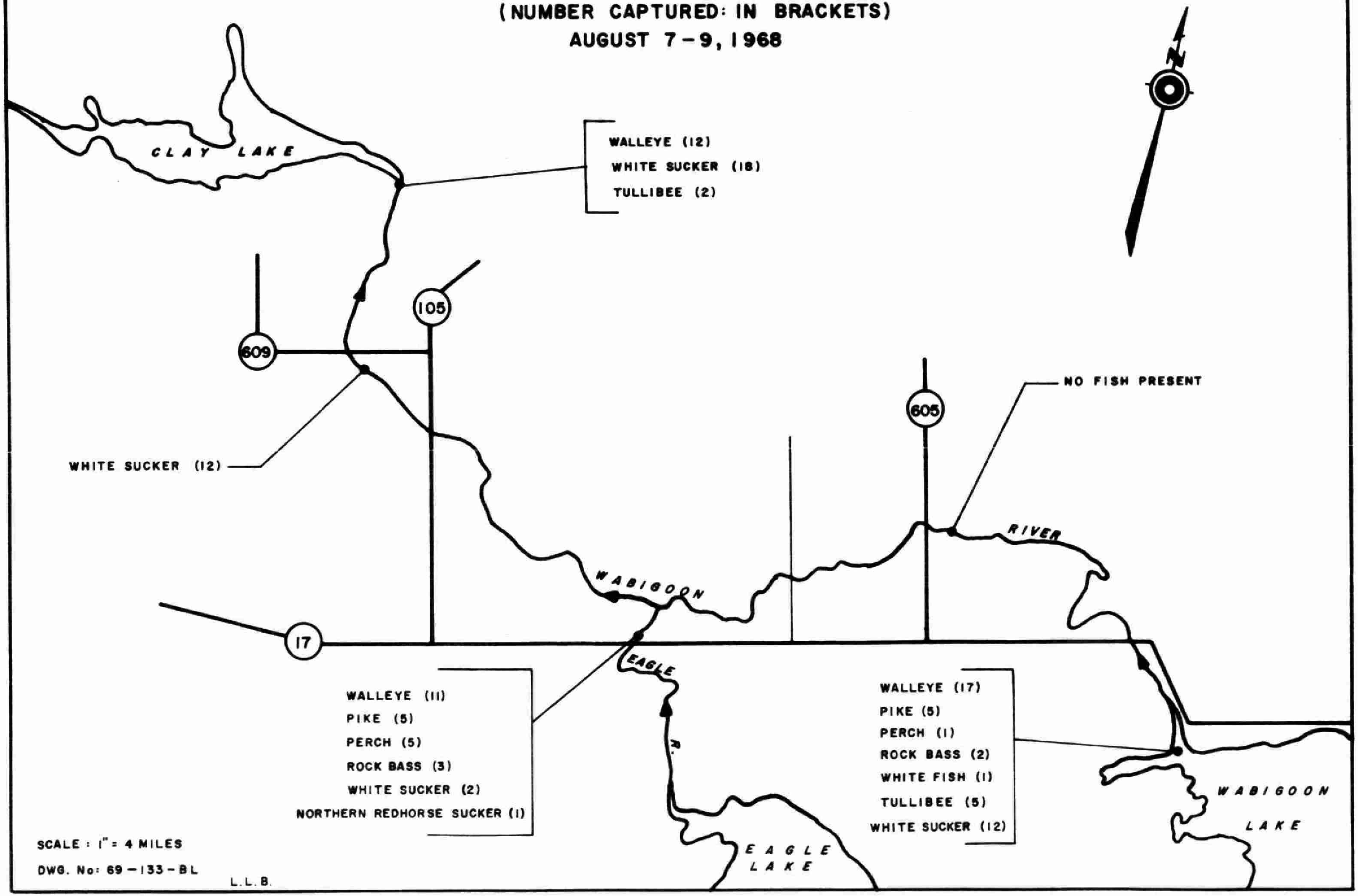
Further indication of the pollution status of the Wabigoon River is provided by comparing bottom fauna communities above and below the paper mill discharge. The term bottom fauna refers to animal life visible to the unaided eye, which live either in or on the sediments at the bottom of the river or lake. Because of the varied, responsive and immobile nature of a bottom fauna community, as well as its importance as a source of fish food, this group of animals represents one of the most useful forms of aquatic life for making an accurate assessment of water quality.

FIG. -2

DISTRIBUTION OF FISH IN THE WABIGOON RIVER

(NUMBER CAPTURED: IN BRACKETS)

AUGUST 7-9, 1968



WALLEYE (12)
WHITE SUCKER (18)
TULLIBEE (2)

WHITE SUCKER (12)

NO FISH PRESENT

WALLEYE (11)
PIKE (5)
PERCH (5)
ROCK BASS (3)
WHITE SUCKER (2)
NORTHERN REDHORSE SUCKER (1)

WALLEYE (17)
PIKE (5)
PERCH (1)
ROCK BASS (2)
WHITE FISH (1)
TULLIBEE (5)
WHITE SUCKER (12)

SCALE : 1" = 4 MILES

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Table 2 indicates the results of bottom fauna investigations on the Wabigoon River and control tributaries, condensed to total numbers of major taxa per transect. A complete list of taxa identification is too lengthy to append; however, data are permanently recorded on OWRC file cards 68B275 to 68B590 inclusive. In Figure 3, the longitudinal changes in percent frequency of occurrence of several of these groups are illustrated. From the data secured, bottom fauna communities of the Wabigoon River between Wabigoon Lake and Clay Lake define four distinct zones of water quality.

Water of good quality was apparent in the Wabigoon River upstream from the pulp mill effluent and water of comparable quality existed in the Eagle River tributary and the Rugby Creek and Gullwing Creek tributaries. Benthic communities from these locations were characterized by a variety of species, low densities and the frequent occurrence of mayflies, alderflies and caddisflies, forms which can survive only in clean water.

Gross water quality impairment was evident between the pulp mill effluent and the Eagle River tributary, a distance of 27 miles downstream from Dryden. The restricted nature of the benthic communities and numbers of organisms strongly suggests that toxic pollution exists throughout this reach of the river. Of the 35 samples obtained between the pulp mill effluent and Eagle River, six were void of macroinvertebrate life, a further 14 samples contained ten or fewer organisms and the remainder produced only relatively low densities of pollution-tolerant sludgeworms and midges.

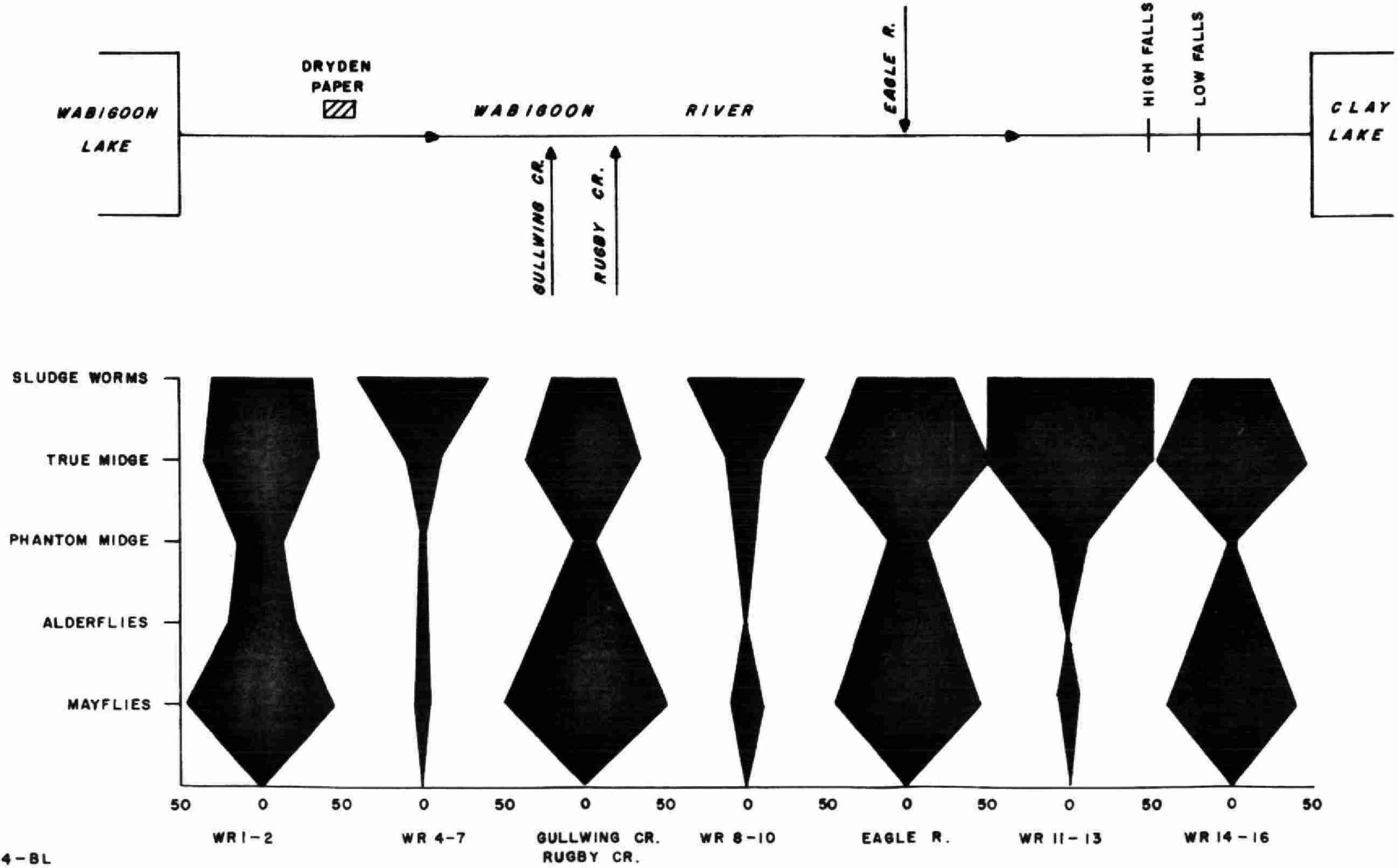
A notable improvement in water quality was evident below the clean water inflow of the Eagle River. Fifteen

Table 2. Distribution and abundance of major taxonomic groups of bottom fauna secured from the Wabigoon River and tributaries during June and July, 1968.

	GC	RC	ER1	ER2	WR1	WR2	WR4	WR5	WR6	WR7	WR8	WR9	WR10	WR11	WR12	WR13	WR14	WR15	WR16
Mayflies	14	56	113	54	40	59			2			1	4		1		16	68	112
Caddisflies		1	4	3	2	1											2		1
Alderflies	3	27	4	18		9		1										10	9
Dragonflies				1															
Dipterans	17	10	66	25	23	14			3	4	6	1		212	231	294	14	35	39
Bugs			1			1													
Beetles			1	1															
Amphipods			34	21	8											1	7		2
Crayfish						1													
Clams	26	12	2	2		4								481	26	5	41		8
Snails		27	2	24										1			52		
Leeches		1	1											1	1		2		
Sludgeworms	9	1	35	2		2	4	79	259	140	124	9	13	13,300	1,350	824	200	7	4

FIG -3

PERCENT FREQUENCY OF OCCURRENCE OF FIVE TAXA OF MACRO INVERTEBRATES SECURED IN SAMPLES FROM SELECTED RANGES ON THE WABIGOON RIVER SYSTEM DURING JUNE - JULY, 1968



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benthic samples were secured between the Eagle River tributary and High Falls, at the 27-mile and 39-mile ranges. These samples, in comparison to the upstream collections, produced large numbers of sludgeworms and midges as well as a good variety of clams and snails, which, as a group, are unable to withstand severe pollution but are capable of surviving in the presence of moderate pollution. While these findings indicate the absence of toxic conditions and a general improvement in water quality, the failure of mayflies, alderflies and caddisflies to re-establish suggests that the return to normal water quality was incomplete at the 39-mile range.

With re-aeration provided by High Falls and Quibell Falls, re-establishment of water quality suitable for the sustenance of a normal bottom fauna appeared complete. Between High Falls and Clay Lake, bottom fauna were returned to conditions present upstream from the discharge of the pulp mill effluent both with respect to the variety and number of organisms present.

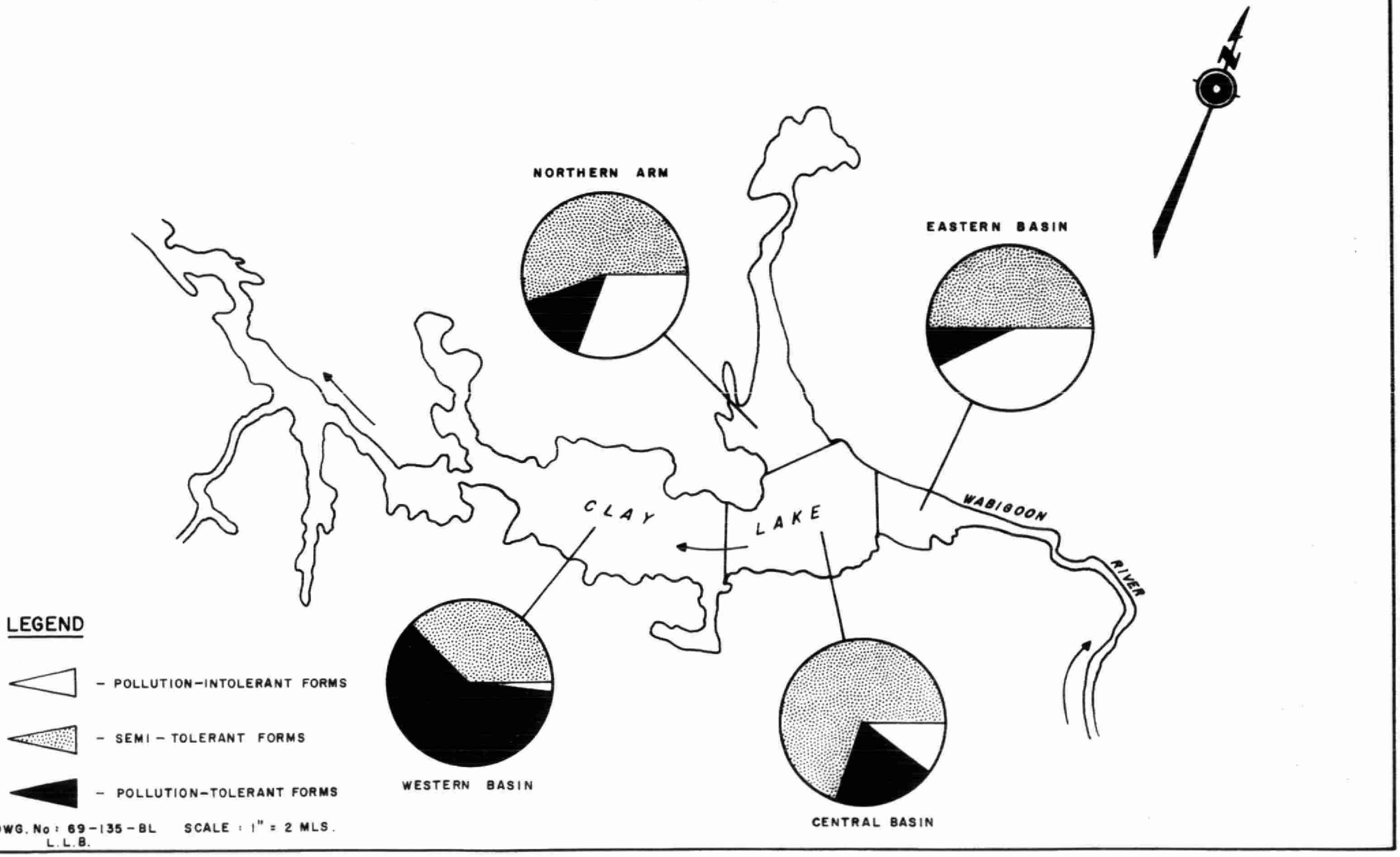
It is worthy of note that the re-establishment of a normal bottom faunal population takes place several miles closer to the pulp mill than the corresponding re-establishment of game fish.

While return to normal benthic communities was complete in the Wabigoon River below High Falls, some form of delayed or secondary effect was revealed by the composition of bottom fauna in Clay Lake.

Figure 4 illustrates the east to west change in composition of the benthic communities of Clay Lake. These data, along with corresponding information from three control lakes - Wabigoon, Rugby and Eagle, all contiguous to the Wabigoon River, are provided in Table 3. Each of

FIG. -4

PERCENT COMPOSITION OF BOTTOM FAUNA COMMUNITIES
IN CLAY LAKE, JUNE - JULY, 1968



the control lakes, as well as the northernarm and eastern portion of Clay Lake, produced well-balanced benthic associations indicative of good water quality. In contrast, the western basin of Clay Lake produced mainly pollution-tolerant sludgeworms and midges. Further evidence of water quality degradation in the western basin of Clay Lake is provided in the following section.

Table 3. Percent composition of the bottom fauna of Clay, Wabigoon, Rugby and Eagle lakes during June and July, 1968.

	No. of samples	Intolerant forms (%)	Tolerant forms (%)	Semi-tolerant forms (%)
Clay Lake				
Eastern basin	15	36.7	14.0	49.3
Northern arm	10	30.5	13.8	55.7
Central basin	35	10.9	18.2	70.9
Western basin	30	1.5	59.3	39.2
Wabigoon L.	50	68.0	2.6	29.4
Rugby Lake	15	18.1	0.8	81.1
Eagle Lake	35	82.1	2.8	15.1

Intolerant forms - mayflies,caddisflies and alderflies
Tolerant forms - sludgeworms and midge
Semi-tolerant forms - snails, clams, leeches, etc.

Dissolved oxygen

In a river situation, oxygen is continually being utilized for community metabolism and replenished by diffusion from the atmosphere and the photosynthetic activity of plants.

Under normal conditions, the net result is a continuous supply of dissolved oxygen sufficient to maintain a viable population of fish and their food organisms. Where man's activities impose an artificial demand on the oxygen resource, the river's capacity to replenish and maintain satisfactory concentrations of dissolved oxygen is directly related to the level of waste loading. Moderate loadings may be adequately handled by the river without affecting aquatic life, whereas excessive loadings may cause severe oxygen depletion to a level where aquatic life is jeopardized.

From an industrial wastes survey of the Dryden Paper Company Limited, carried out during the period July 16 to July 21, 1968, the BOD5 loading was estimated at 85,000 lbs/ day. This represents an oxygen demand greater than twice the cumulative demand of the raw sewage discharge from the total population of Northwestern Ontario.

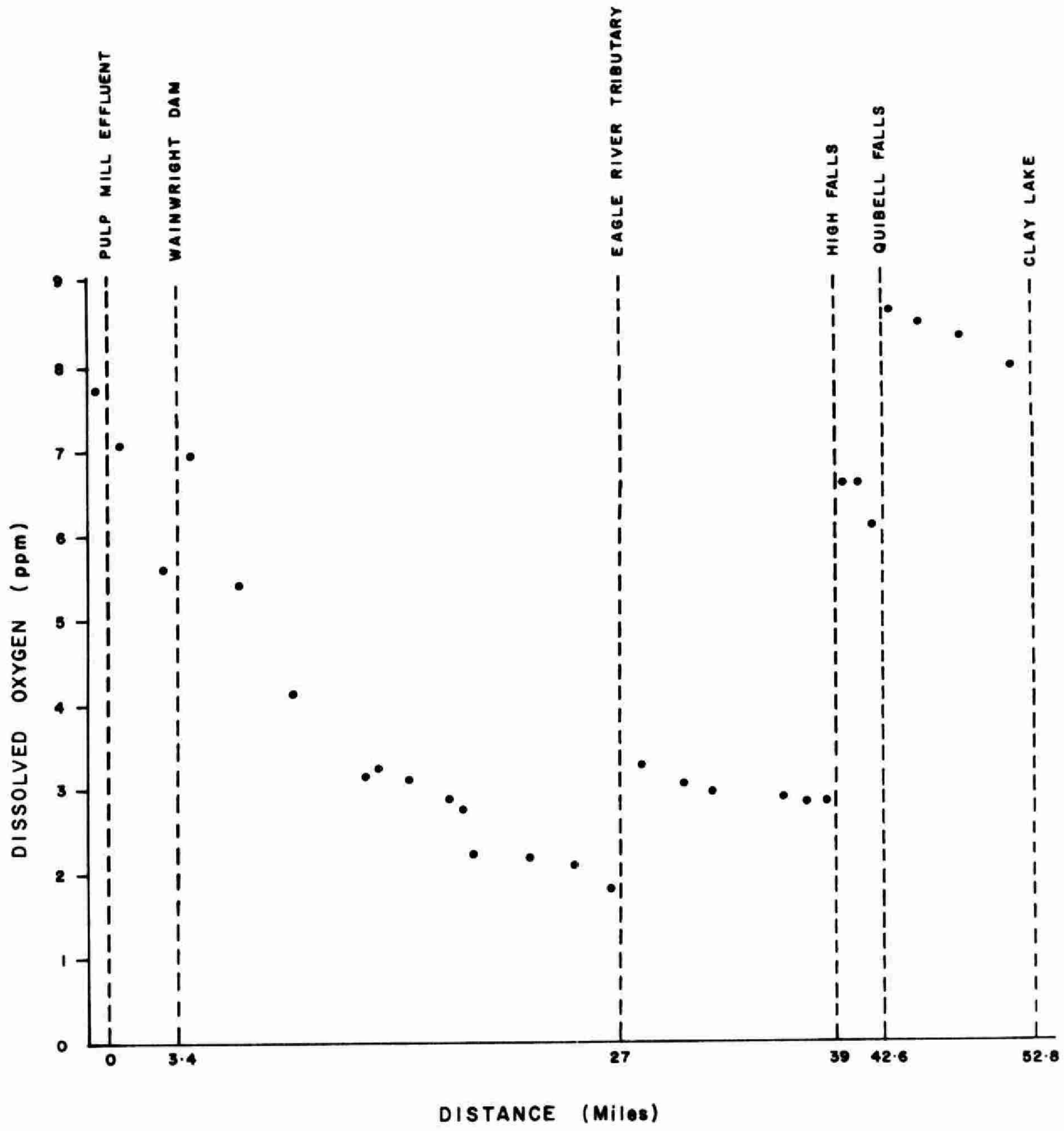
The dissolved oxygen profile of the Wabigoon River is illustrated in Figure 5. Changes in dissolved oxygen between Dryden and Clay Lake parallel identically the recorded range restrictions of fish and fish food organisms.

Severe depletion of dissolved oxygen was observed to a distance of 39 miles downstream from the discharge of the Dryden Paper Mill effluent. The extreme low of less than 2 ppm (average) occurred at a location approximately 27 miles downstream from the mill and just upstream from the Eagle River tributary.

Below High Falls and Quibell Falls dissolved oxygen levels re-bound to near saturation, owing to the extensive re-aeration provided. Between Quibell Falls and Clay Lake, dissolved oxygen is maintained above a safe level for normal

FIG. -5

DISSOLVED OXYGEN PROFILE OF THE WABIGOON RIVER SEPTEMBER, 1968 (WATER QUALITY SURVEYS BRANCH)



DWG. No: 69-171-BL

benthic production. This accounts for the re-establishment of indigenous aquatic life. However, a gradual downstream decline in dissolved oxygen occurs below Quibell Falls (see Figure 5). This indicates that the assimilation of pulp mill wastes is incomplete at the river discharge to Clay Lake and provides a possible explanation for the degraded quality in Clay Lake.

Between June 14 and July 13, dissolved oxygen levels at the surface averaged 8.1 ppm in the upstream Wabigoon Lake and 6.2 ppm in the downstream Clay Lake. These values represent 15 determinations from Wabigoon Lake and 10 determinations from Clay Lake.

During the September survey, the epilimnetic (surface) and hypolimnetic (bottom) oxygen levels were measured at six locations in Clay Lake. These results are provided in Table 4. At each of these locations, the hypolimnetic waters contained less than 5 ppm dissolved oxygen, the level considered essential to support and maintain healthy populations of warm water fishes.

Table 4. Dissolved oxygen levels measured at six locations in the Western Basin of Clay Lake during September, 1968. All values represent an average of nine measurements.

Location	Depth (ft.)	Dissolved oxygen (mg/l)	Temperature (°C)
1 North	0	6.8	17.5
	42'	4.0	15.0
1 Central	0	6.8	17.5
	50'	2.9	14.8
1 South	0	6.7	17.5
	42'	4.0	15
2 North	0	6.7	17.8
	45'	3.3	15.5
2 Central	0	6.6	17.5
	40'	4.6	15.5
2 South	0	6.9	17.8
	45'	2.9	14.7

Odour

It has frequently been reported from on-the-spot observations that the surface waters of the Wabigoon River and Clay Lake have an offensive odour. In order to document the odoriferous properties of the Wabigoon River, eight samples of surface water were collected from various ranges along the river and tested for odour in the laboratory. In the laboratory, the occurrence of unnatural odours in water is detected and quantified by the Threshold Odour Number (T.O.N.) which represents the number of times an odour-bearing water must be diluted to obtain a concentration at which the odour is barely perceptible. The findings of threshold odour determinations on water samples secured from the Wabigoon River are listed in the table below.

Table 5. Threshold odour levels of the surface water of the Wabigoon River, July, 1968.

Station	Threshold Odour Number - Geometric Mean
WR2	19.6
Effluent*	200.0
WR4	200.0
WR8	200.0
WR9	200.0
ER2	13.4
WR13	17.1
WR14	18.4

* Effluent - sample of final effluent as discharged to the river from Dryden Paper Company Limited.

These results indicate that odourous wastes originating at the point of discharge from Dryden Paper Company Limited are present in the Wabigoon River downstream to its confluence with the Eagle River. Downstream from that point no significant odour was detected. River flow was abnormally high at the time these samples were secured and it is possible that under more typical river flows odour would be detectable further downstream.

Suspended wood fibre

From an industrial waste survey of the Dryden Paper Company Limited carried out during the period from July 16 to July 21, 1968, the waste loading of suspended solids sewered to the river was established to be between 65,500 and 141,000 lbs/day. Wasted wood fibre is a major component of these suspended solids. In order to establish the longitudinal distribution and abundance of wood fibres in the Wabigoon River, water samples were secured on July 17, 1968 from six sampling ranges and examined by microscopic methods as outlined on page 9. These results are provided in Table 6. As indicated by these findings, nearly all of the wood fibre sewered to the Wabigoon River is deposited to the river bottom between the mill and the 20-mile range. No fibre was present upstream from the pulp mill and only a trace of wood fibre was detected at the 40-mile range.

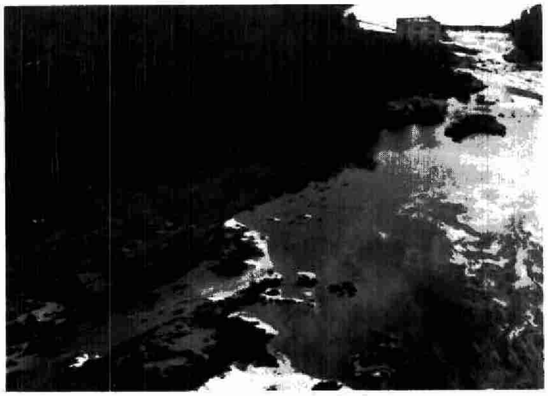
Wood fibre in the aquatic environment constitutes a source of long-term residual demand on the river's dissolved oxygen resource, blankets and destroys fish spawning beds and the habitat of fish food organisms, may bring about a wide variety of sub-lethal effects on fish life and on decomposition may liberate gaseous by-products which are acutely toxic to aquatic life. In addition to these, wood fibre may seriously disrupt the aesthetic properties of the receiving water.

Table 6. Longitudinal distribution and abundance of suspended wood fibre in the Wabigoon River, July 1968.

Station	Distance from mill		Wood fibre in areal standard units
WR2	½ mile upstream		0
WR5	3 miles	downstream	5,100
WR7	15 miles	"	5,000
WR9	20 miles	"	700
WR11	28 miles	"	300
WR13	39 miles	"	100

Precipitated pulp wastes

Naturally-occurring bottom deposits of the Wabigoon River consisted of a clay base overlain by soft mud with some isolated patches of sand. Upstream from Dryden, bark originating from booming operations was widely distributed. Between the mill and Wainwright Dam, natural sediments were completely blanketed by a deep accumulation of bark and coarse wood chips. From Wainwright Dam to range WR11 (28 miles) wood fibre was the principal component of the substrate. Also, wood fibre occurred in isolated beds as far downstream as Highway 105, a distance of nearly 40 miles. Table 7 indicates the lateral and longitudinal distribution of deposited pulp wastes.



Wabigoon River below Wainwright Dam. Note exposed sludge beds at low river flow. July, 1968.

Table 7. Components of the substrate at bottom fauna sampling stations on the Wabigoon River, 1967.

Transect	Left*	Left centre	Centre	Right centre	Right
WR1	B,S,C	B,C	B,C	B,S	B
WR2	B,C	B,C	B,C	B,C	B,C
WR4	Bc	Bc	Bc	Bc	Bc
WR5	Bc	Bc	Bc	Bc	Bc
WR6	B,F	B,F,S	B,F	Bc,F	Bc,F,C
WR7	F,C	F,C	Bc,F	F,C	F,C
WR8	F,C	F,C	C	C	F,C
WR9	F,C	B,C	F,C	F,C	F,C
WR10	F,C	Bc	F,C	F,C	F,C
WR11	F,C	F,C	F,C	F	F,C
WR12	F,C	S,C	C	C	F,C
WR13	C	F.C	S,C	S,C	F,C
WR14	C	C	C	C	Bc,S
WR15	S,C	S,C	S,C	S,C	S,C
WR16	C	S,C	S	S,C	S,C
GC	C	C	C	C	C
RC	C	C	C	C	C
ER1	S,C	S,C	S,C	S,C	S,C
ER2	C	C,S	S,C	S,C	C

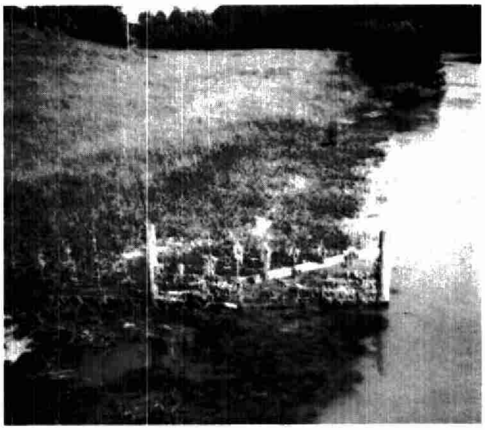
* Facing Downstream

Key:
B - bark
Bc - bark & chips
F - fibre
S - sand
C - clay

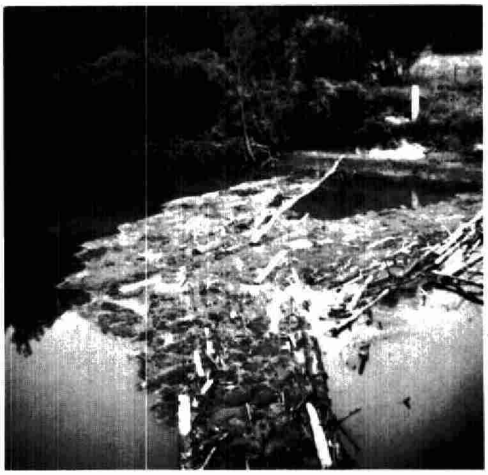
Aesthetic conditions

In preceding sections of this report, the presence and extent of water quality impairment and resultant destruction of aquatic life has been described. Of equal concern and perhaps greater public impact is the physical condition of the river at public vantage points.

In general, substantial alteration of the river's natural amenities exists to a distance of approximately 27 miles downstream from the mill discharge. At that location, conditions improve considerably owing to dilution from the Eagle River. Throughout this upper river reach, the river was an unsavoury mess of discoloured, bubbling, foaming and odiferous water, surrounding massive exposed sludge beds and floating islands of pulp wastes. Table 8 provides a summary of conditions observed on the Wabigoon River during June and July, 1968.



Wabigoon River at Minnitaki Road, 20 miles below mill discharge. Note litter of pulp wastes after high flow period. July, 1968.



Same Minnitaki Road location. Note blockage of river navigation by logs and fibre mats. July,1968.

Table 8. Visible conditions of the Wabigoon River during June and July, 1968.

Range (miles from mill)	General appearance	Colour	Foaming potential	Exposed sludge banks	Floating sludge mats	Gas ebullition	Vascular plants	Wildlife
1.5 - 0	normal	grey	slight	nil	nil	nil	present	ducks
0 - 3.5	unsightly	dark-brown	high	massive	present	present	absent	nil
3.5 - 6.5	unsightly	brown	high	massive	present	present	absent	nil
6.5 - 11	unsightly	brown	high	abundant	abundant	active	absent	nil
11 - 15	unsightly	brown	high	abundant	abundant	active	absent	ducks
15 - 20	unsightly	brown	high	present	abundant	active	absent	ducks
20 - 27	unsightly	brown	high	present	present	active	absent	ducks
27 - 28.5	improved	grey	high	nil	present	present	present	ducks, deer, moose,beaver
28.5- 35	improved	grey	high	nil	present	nil	abundant	ducks, deer, moose,beaver
35 - 39	near normal	grey	high	nil	nil	nil	abundant	ducks, deer, moose,beaver
39 - 41	near normal	grey	high	nil	nil	nil	abundant	ducks, deer, moose, beaver
41 - 46	near normal	grey	high	nil	nil	nil	abundant	ducks, deer, moose,beaver
46 - 53	near normal	grey	high	nil	nil	nil	abundant	ducks, deer, moose,beaver

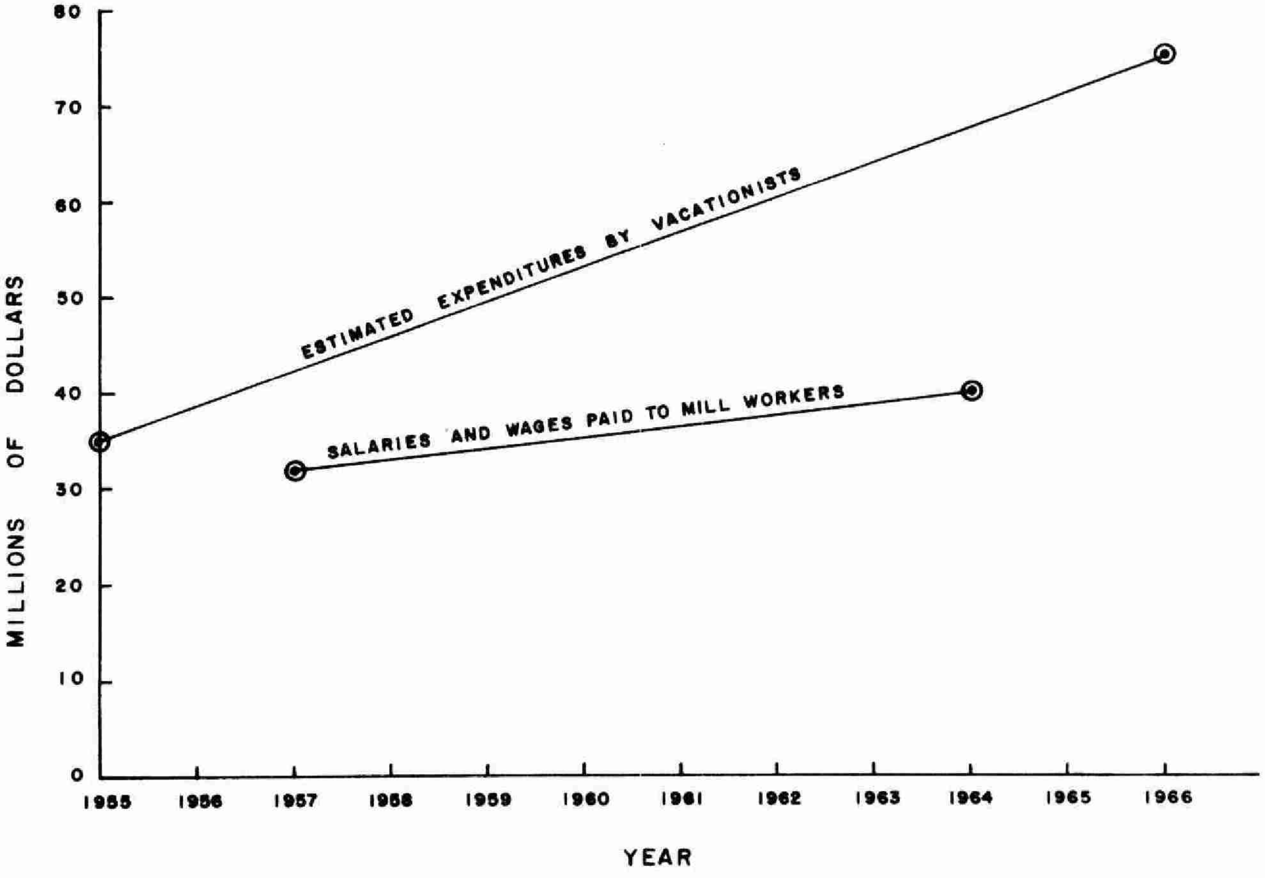
INFLUENCE OF EXISTING CONDITIONS ON MULTIPLE WATER USE

While there is an abundance of unpolluted, aesthetically attractive and biologically productive bodies of water in the vicinity of Dryden, pollution of the Wabigoon River seriously detracts from the quality of the local environment both as a place of permanent residence and as an area for vacationing. A recent study of tourism in Northwestern Ontario proposed the recognition and development of a historic canoe route on the Wabigoon; along with several other rivers, in order to promote further recreational activity for vacationists(2).

At the regional level, pollution of the Wabigoon River is a major cause for concern to the tourist industry of Northwestern Ontario. In order to clarify the above statement it should be recognized that, at the present time, in terms of dollar earnings, tourism is Northwestern Ontario's third largest industry, surpassed only by the forest-based and mining industries. Future growth predictions for the tourist industry, extrapolated from growth trends over the past decade, indicate that the tourist industry will in the near future challenge forestry and mining as the region's leading dollar earner. As an indication of the rate of growth of the tourist industry of Northwestern Ontario, data from the Dominion Bureau of Statistics relative to the estimated expenditures of vacationists and the salaries paid to mill workers of the pulp and paper industry of Northwestern Ontario are illustrated for comparison in Figure 6. Reference to the aforementioned report on tourism should be made for further information concerning the status of the tourist industry in Northwestern Ontario.

FIG. – 6

ESTIMATED EXPENDITURE OF VACATIONISTS AND THE SALARIES AND WAGES PAID TO MILL WORKERS OF THE PULP AND PAPER INDUSTRY NORTH-WESTERN ONTARIO (DOMINION BUREAU OF STATISTICS)



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At the present time, there is little or no utilization of the Wabigoon River other than for translocation and assimilation of wastes and limited hydropower generation. As previously documented, this has not always been the situation. Uses which have either been eliminated or precluded owing to pollution by pulp mill wastes include boating, swimming, sport and commercial fishing, agricultural utilization, hiking, camping and other activities dependent on an aesthetically-pleasant environment.

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